# *Framework for Placement of BMPs in Urban Watersheds*

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# ISMDSF

## Integrated Stormwater Management Decision Support Framework

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# Outline

- Project objective
- Cost-optimization concept
- Framework Design
- Two-phase effort

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# *OBJECTIVE of ISMDSF*

Develop methodologies and decision-support tools

for cost-effective placement of BMPs at strategic locations in urban watersheds

based on integrated data collection and hydrologic, hydraulic, and water quality modeling

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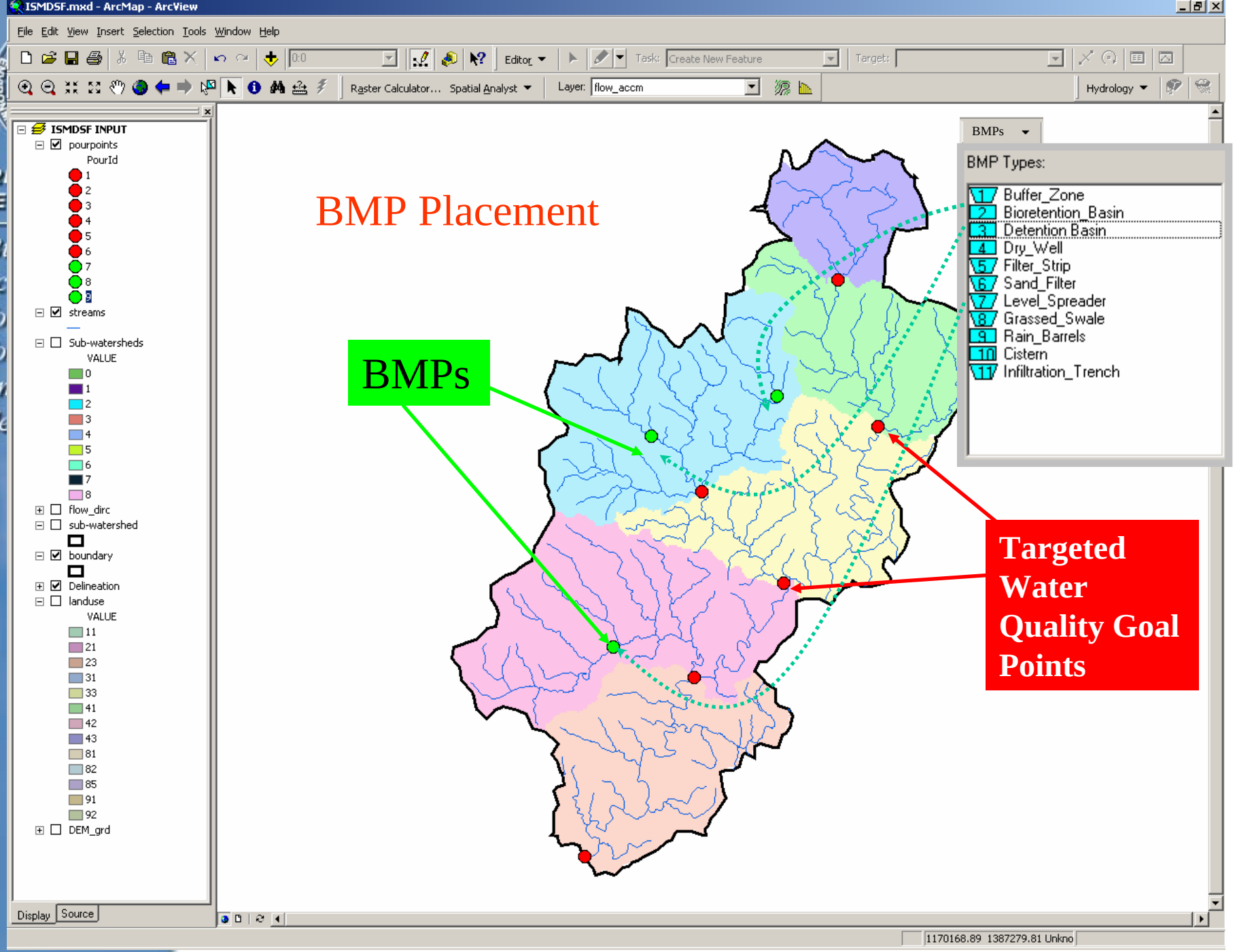
# *Placement Strategy*

- Trade-offs
  - In a given subwatershed
    - Upstream distributed BMP/LID options
    - Downstream more regionalized wet-retention basin/wetland systems
  - Between sub-watersheds


ISMDSF.mxd - ArcMap - ArcView
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DEM_grd
Display
Source
BMP Placement
BMPs
BMPs
BMP Types:
1 Buffer_Zone
2 Bioretention_Basin
3 Detention Basin
4 Dry_Well
5 Filter_Strip
6 Sand_Filter
7 Level_Spreader
8 Grassed_Swale
9 Rain_Barrels
10 Cistern
11 Infiltration_Trench
Targeted Water Quality Goal Points
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# *Intended Users*

- Knowledgeable model users who are familiar with the technical aspects of watershed modeling – including:
  - *Local/county government engineers/planners*
  - *Federal/state regulatory reviewers*
  - *Consulting engineers*
  - *Public concerned citizens/stakeholders*
  - *Academicians*
- Not intended for modeling neophytes.

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# *Desired General Features of ISMDSF*

- Functional capability within the framework
- Ability to link externally to existing watershed and receiving water models
- Current trends in system development
- Ability to build on the existing framework while allowing for parallel development of supporting models

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# *Design Requirements of ISMDSF*

- Oriented for knowledgeable model users
- Include GIS for BMP strategic placement and selection
- Applicable to mixed land use urban watersheds
- Include hydrologic/hydraulic/water quality process modeling
- Able to compare cost-effectiveness of alternatives

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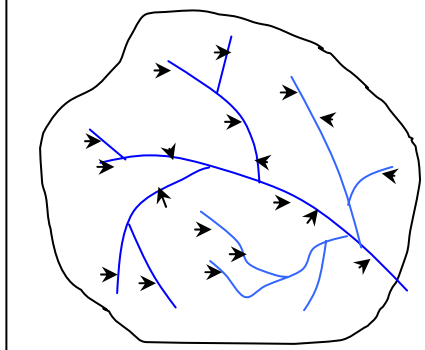
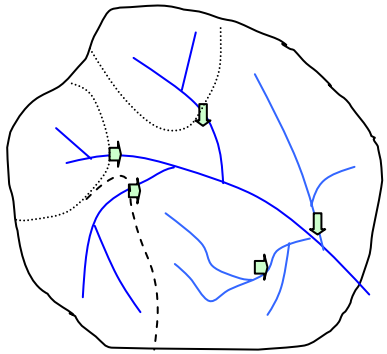
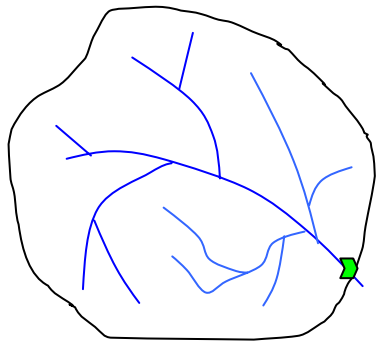
# BMP Placement at Various Spatial Levels



(a) On-site BMPs



(b) Sub-regional BMPs



(c) Regional BMPs

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# Comparisons of Modeling Frameworks

- BASINS
  - Large-mid size watershed
  - Primarily Rural
  - Mixed land uses
  - Limited BMPs
  - River/simple lake
    - Steady state river
    - 1-D routing
- TMDL Toolbox
  - Large-mid size watersheds
  - Primarily Rural
  - Mixed land uses
  - Limited BMPs
  - River/lake/estuary
    - Hydrodynamic
    - Water quality
  - Extensions
    - Sediment
    - Mercury
- ISMDSF
  - Mid-small watersheds
  - Urban
    - Sewer Routing (SWMM)
  - Mixed land uses
  - BMP simulation
    - Placement
    - Optimization
  - Receiving water
    - 1-D stream routing within the watershed
    - External linkage to river/lake/estuary models

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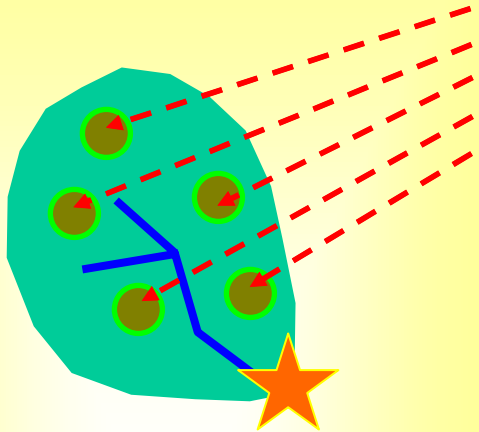
# *ISMDSF*



## Feasible Option Matrix

| Potential Location | BM | ration | |
|---|---|---|---|
| 1 (0-1) | | ce area | ... |
| 2 (0-1) | | area | ... |
| ... | | | ... |

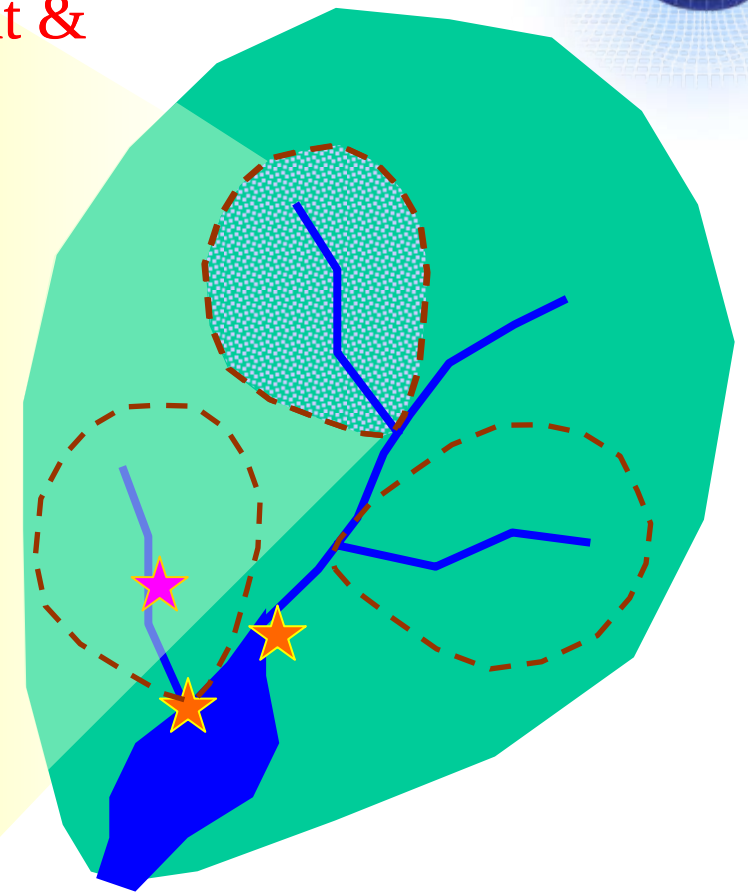
Decision Optimization Engine

★ Target Load Reduction

● BMP Locations

## Site-Level BMP Placement & Design

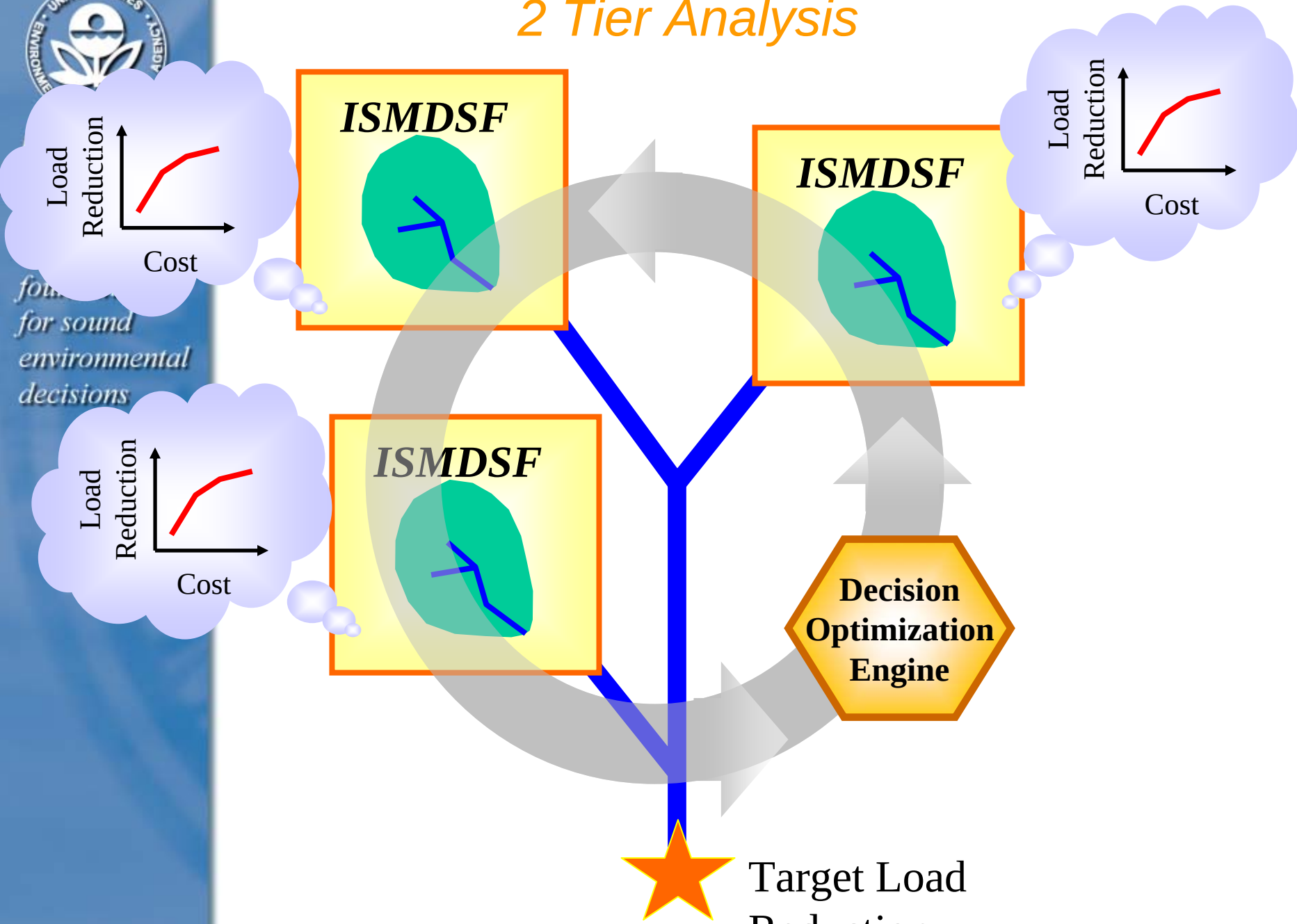
Large Watershed



★ Load (reduction) Allocation

★ Waste Load (reduction) Allocation

# 2 Tier Analysis

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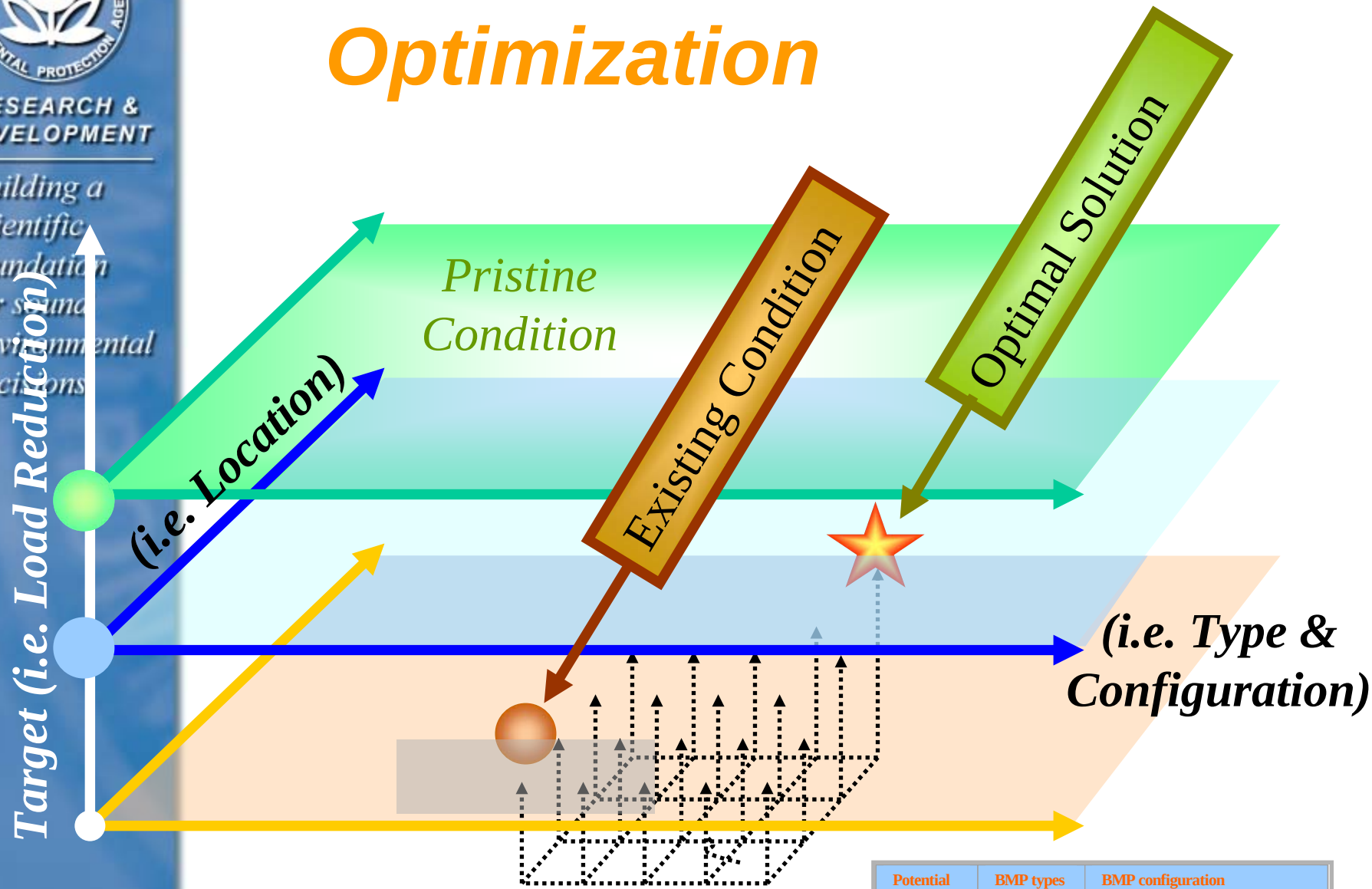
# Optimization




**Feasible Option Matrix**

| Potential Location | BMP types | BMP configuration | | |
|---|---|---|---|---|
| 1 (0-1) | A, B, C… | Depth | Surface area | … |
| 2 (0-1) | A, B, C… | Depth | Surface area | … |
| | | | | |

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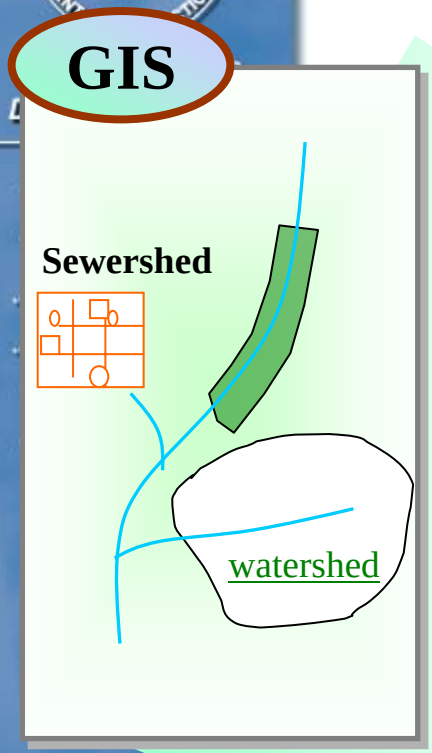


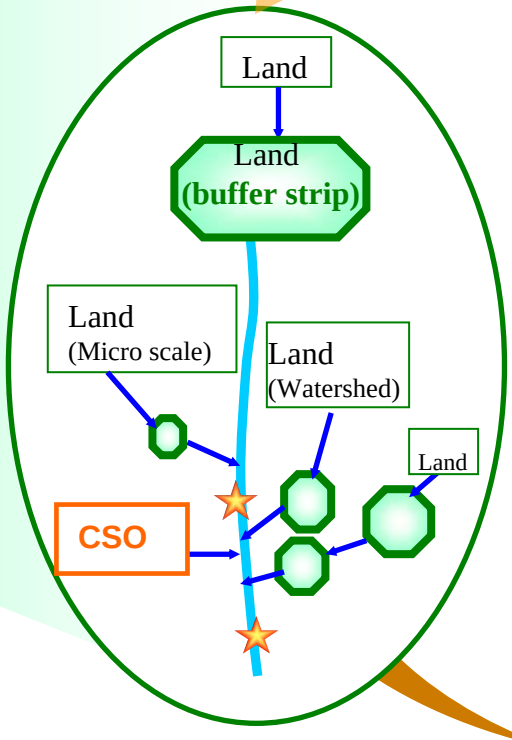


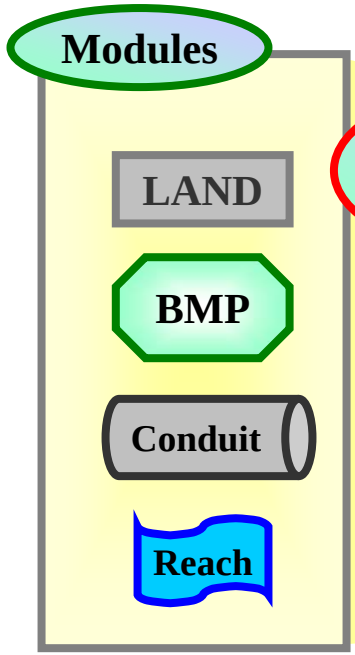


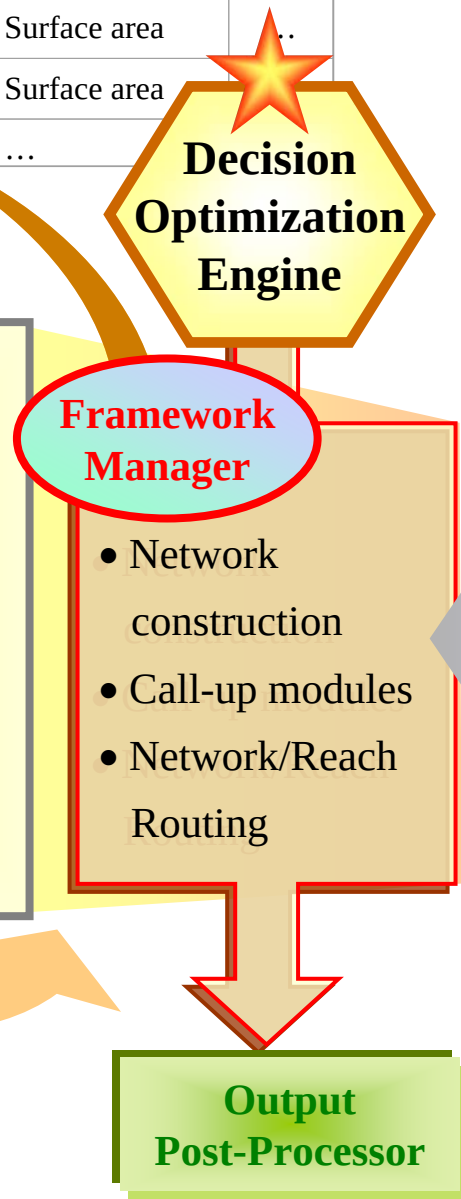

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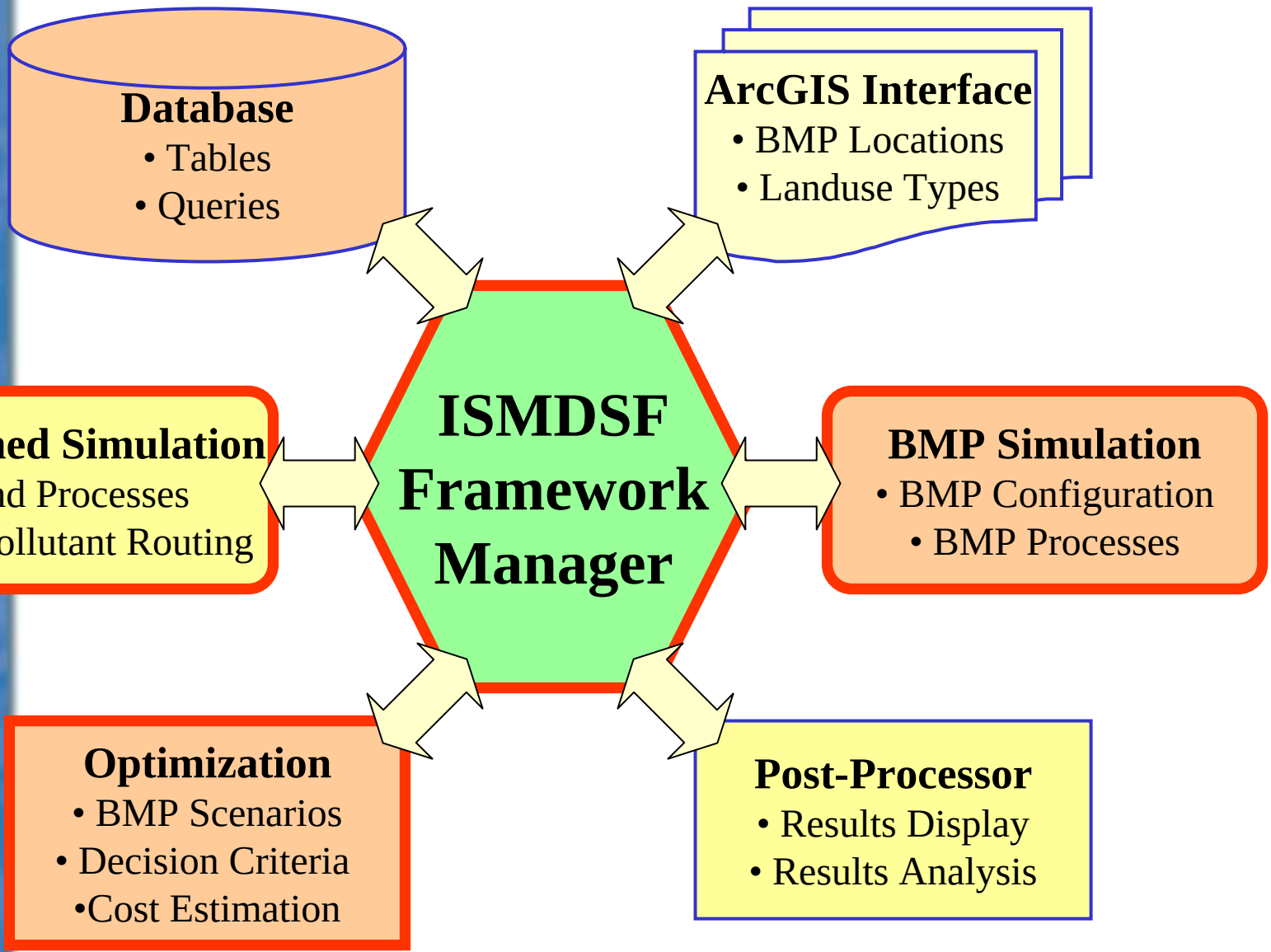

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# *Framework Manager*

- The *command center* of ISMDSF
- Establishes the modeling network from GIS database
- Calls ISMDSF components (watershed and BMP modules, post-processor, optimization engine) as needed
- Provides feedback to all components
- Uses Visual Basic programming language

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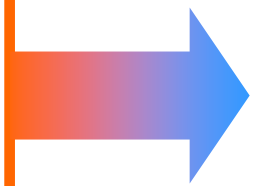
# Watershed Model Processes

*Land Surface and Subsurface*

- Surface Runoff Simulation
  - Rainfall Runoff/Infiltration
  - Erosion
- Subsurface Hydrology
  - Baseflow/Interflow
  - Soil moisture conditions
- Water Quality
  - Surface pollutant accumulation & wash-off
  - Subsurface pollutant transformation
  - Transport from surface & subsurface

*Routing*



*To Pipe, Stream,*

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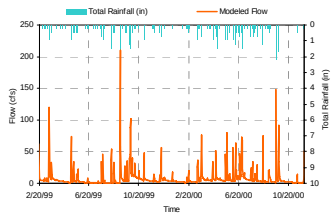
*Routing*

*From Land*

# *Watershed Model Processes*

*Pipe/Channel Routing and Transport*

- Urban Stormwater Routing
  - Sewer network definition
  - Conduit transport/overflow/bypass
  - Intermediate storage
- Natural Channel Routing
  - Reach routing network
  - Land-to-Land (stream buffer)
- Instream Water Quality
  - Pollutant delivery to conduit/channel
  - Instream pollutant transformation




*Time-series*

*Flow & WQ*

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# *Stand-alone Watershed Models – mostly from SWMM*

- **Land** – watershed/landscape runoff simulation
- **BMP** – process simulation of a BMP
- **Conduit** – flow and pollutant routing through a conduit network
- **Reach** – flow and pollutant routing through an open channel network

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# BMP Simulation

- Input time series (from land simulation)
- BMP process simulation (occurs at nodes)
- Based on the current Prince George's County BMP Model
  - Structural BMP
    - Class A – storage/detention
    - Class B – open channel
  - Non-structural BMP
    - Represented at the land-simulation stage

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# ArcGIS Interface

- Serves as the system interface (What the user sees)
- Access GIS functions through a series of menus, buttons, and dialog boxes:
  - Parcel delineation
  - Network generation
  - Read/edit spatial and tabular data sets
- Dynamic interaction with other components
- Visual Basic programming language with ArcObjects
- Required software: ArcView 8 and Spatial Analyst

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# Optimization

- Problem formulation
  - Objectives & constraints
  - Evaluation factors & assessment points
  - Potential BMP types and locations
- Solution techniques
  - Scatter search
  - Genetic algorithm

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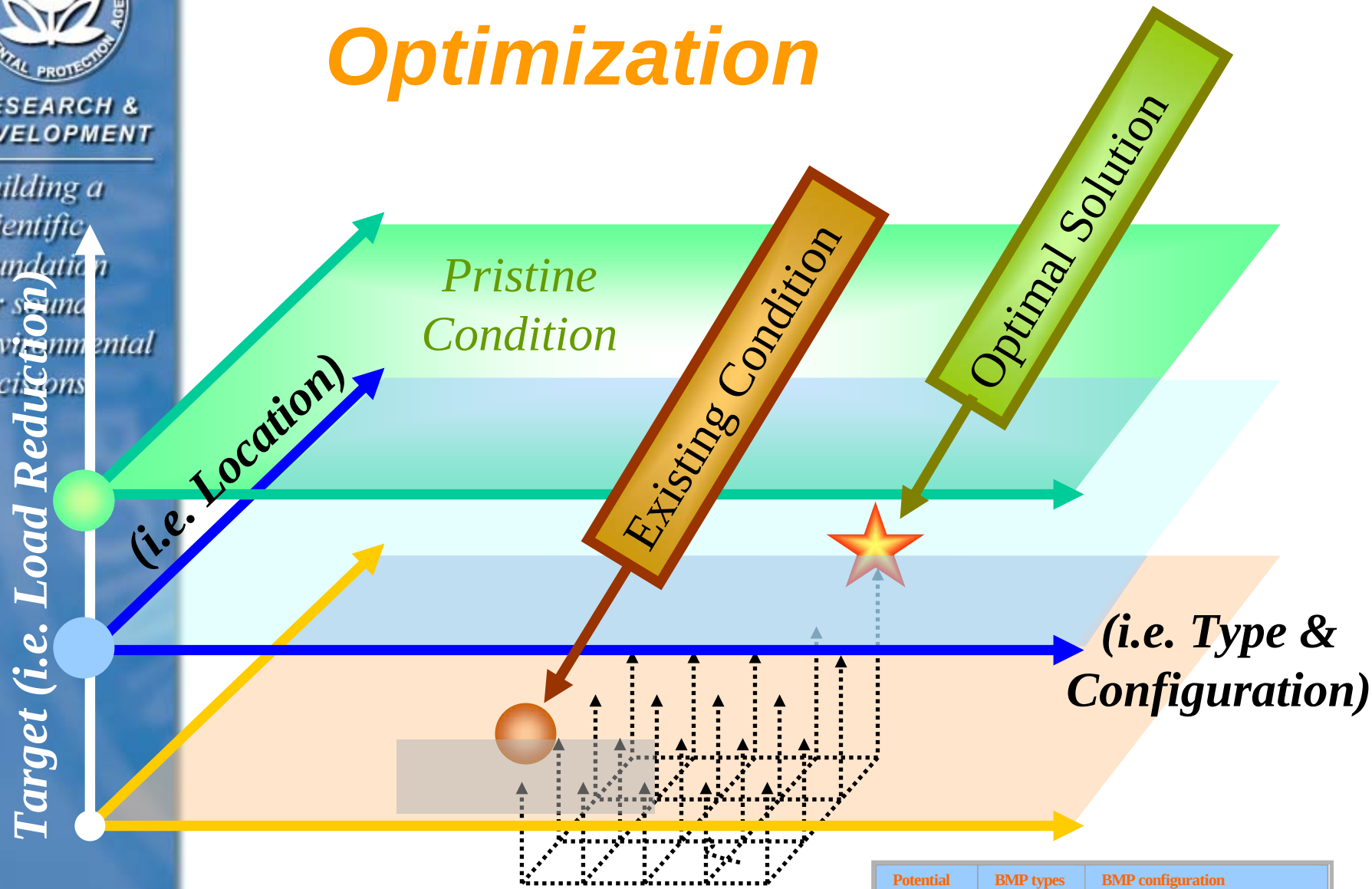
# Optimization

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| | | | | |

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# Database

- Microsoft Access database
- Seamlessly integrated with GIS Interface
- Data management platform for spatially associated features
- Interaction/data exchange with other components
- Required software: MS Access or Microsoft Access Driver

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# *Post-Processor*

- Results visualization and tabulation
- Scenario comparison and analysis
- Summary results and statistics
- Seamless integration with ISMDSF components
- Accessible through the ArcGIS interface
- VBA macro programming language
- Required software: MS Excel

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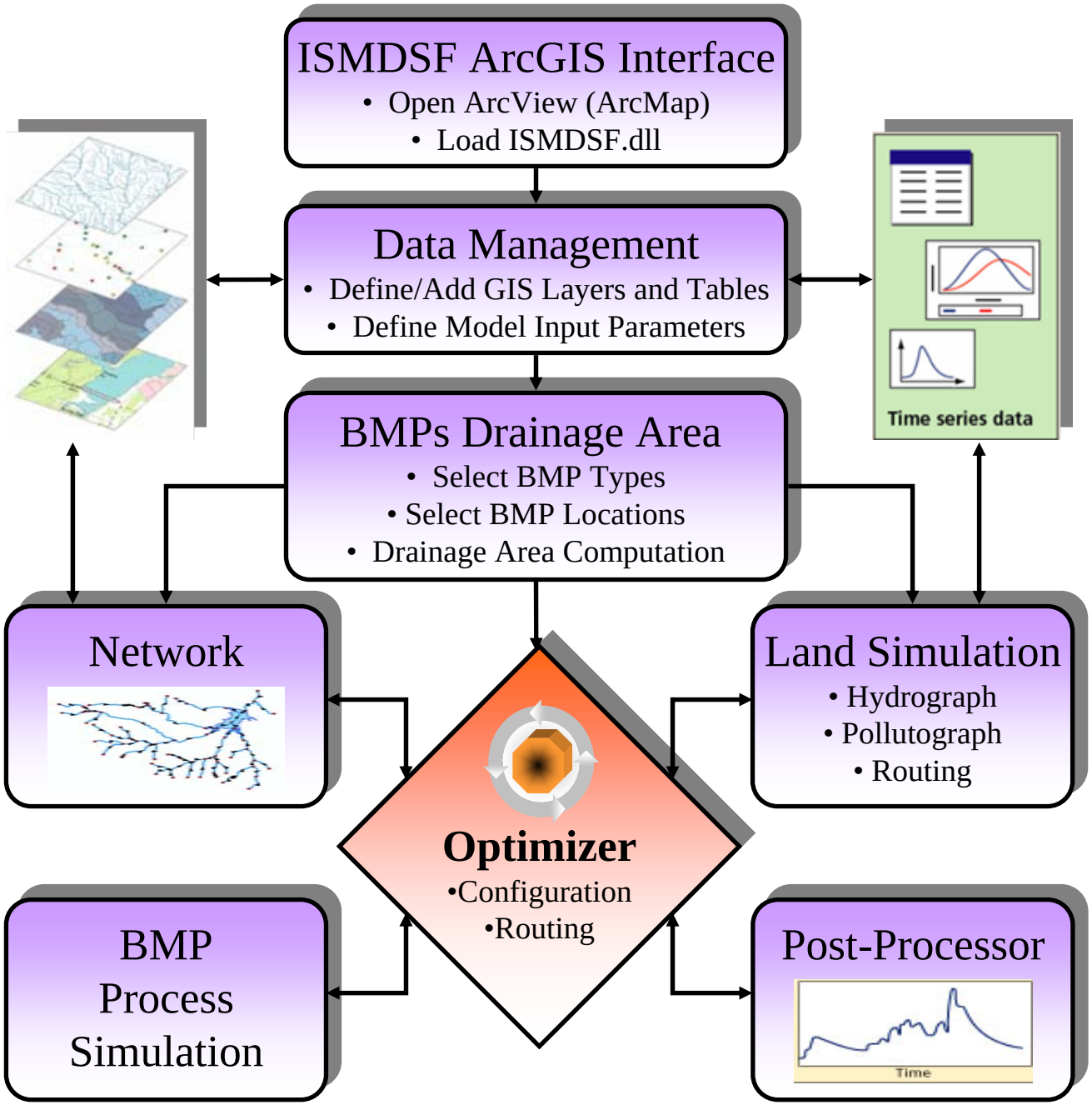

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# Phase 1

- ***Interface***
  - GIS linkage for placement of BMPs
  - GIS based network development capabilities
- ***Cost***
  - Basic cost categories as part of the optimization framework
  - User can enter cost basis data for BMPs
- ***Simulation***
  - Simulation of land, BMPs, and flow network
  - Support for a suite of BMPs including detention, retention, filtration, and buffers
  - Ability to manually set up and evaluate scenarios with various BMP placement and selection options
  - Case study application demonstrating system utility

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# Phase 2

- ***Interface***
  - Enhanced GIS linkage
  - Enhanced functions to setup management options and provide automatic iterations
  - Visualization of BMP placement options
  - Broadened output processing and GIS displays
- ***Cost***
  - Expanded database
  - Cost functions for additional innovative and nonstructural BMPs
- ***Simulation***
  - Development and testing of the optimization component
  - Expanded suite of BMPs
  - System evaluation with new BMP components
  - Application and evaluation of ISMDSF in multiple geographic settings

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# Questions?